

METHOD OF TRANSMITTING DATA BETWEEN DEVICES CONNECTED VIA A  
BUS, AND DEVICE FOR CONNECTION TO OTHER DEVICES VIA A BUS

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Background of the Invention:

Field of the Invention:

The present invention relates to a method of transmitting data  
between devices that are connected via a bus, and to a device  
10 that can be connected to other devices via a bus.

Such methods and devices have been known for many years in  
numerous embodiments, and therefore do not require any more  
detailed explanation.

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A possible design of a system in which a plurality of devices  
are connected via a bus is illustrated schematically in  
Fig. 1. Here, the devices which are to be connected are  
designated by the reference symbols N1, N2, ... Nn, and the  
20 bus interconnecting these devices is designated by the  
reference symbol BUS.

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In the system shown in Fig. 1, in principle any of the devices  
N1, N2, ... Nn can transmit data to any other device via the  
bus BUS.

A known problem with data transmissions between devices which are connected to one another via a bus is that the intention is that the transmission of data should take place very quickly and efficiently, but that, on the other hand, it must also be ensured that the data to be transmitted arrives in a fault-free condition.

In the prior art it has not been possible to solve this problem in a completely satisfactory way: either the transmission of data is very fast, but the price to be paid is that it is not reliable under all circumstances; or else, the transmission of data is very reliable, but the price to be paid is that it is not so fast.

#### Summary of the Invention:

The object of the present invention is to provide a method for transmitting data between bus-connected devices and a device that is connectible to other devices via a bus, which overcomes the above-noted deficiencies and disadvantages of the prior art devices and methods of this general kind, and which enables data transmission that is, on the one hand, very fast and efficient and in which, on other hand, it is possible to ensure that the data to be transmitted arrive at the target in a fault-free condition.

With the above and other objects in view there is provided, in accordance with the invention, a method of transmitting data between devices interconnected via a bus, which comprises:

transmitting, in units, data from a first device to one or  
5 more second devices together with information concerning at least one of a transmission and a use of the data;

forming the units at least partly with at least one region defining a given time slot within which the devices transmitting no data can output onto the bus data representing  
10 specific information; and

defining, in the devices enabled for outputting data within the given time slot, settings selected from the group consisting of a setting to determine under which conditions data are to be output within the given time slot, a setting  
15 which data representing information are to be output within the given time slot, and a setting at which points in time within the time slot the data are to be output.

With the above and other objects in view there is also  
20 provided a method of transmitting data between devices interconnected via a bus, which comprises:

transmitting, in units, data from a first device to one or more second devices together with information concerning at least one of a transmission and a use of the data;

forming the units at least partly with at least one region

5 defining a given time slot within which the devices transmitting no data can output onto the bus data representing specific information; and

defining, at least in specific devices, settings selected from the group consisting of a setting to determine which other  
10 devices have to output data within the given time slot, a setting which data representing information are to be output within the given time slot by the other devices, and at which points in time within the given time slot the other devices have to output the respective data.

15 With the above and other objects in view there is also provided, in accordance with the invention, a device for connection to other devices via a bus, comprising means for transmitting data together with information concerning one of  
20 a transmission and a use of the data in units, wherein at least some of the units are formed with at least one region defining a time slot within which the device can output onto the bus data representing specific information, and wherein the device contains settings selected from the group

consisting of a setting determining under which conditions the device has to output data within the time slot, a setting determining which data representing information the device has to output within the time slot, and a setting determining at  
5 which points in time within the time slot the data is to be output.

There is also provided, in accordance with the invention, a device for connection to other devices via a bus, comprising  
10 means for transmitting data together with information concerning one of a transmission and a use of the data in units, wherein at least some of the units are formed with at least one region defining a time slot within which one or a plurality of other devices can output onto the bus data  
15 representing specific information, and wherein the device contains settings selected from the group consisting of a setting determining which other devices output data within the time slot, a setting determining which data representing information has to be output within the time slot by the other  
20 devices, and a setting determining at which points in time within the time slot the other devices have to output the respective data.

In other words, the methods and devices disclosed and claimed  
25 herein are defined in that

the data to be transmitted from a first device to one or more second devices is transmitted, together with information which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot within which the devices transmitting no data can output onto the bus data representing specific information, and that, in the devices which must be able to output data within said time slot, settings are made to determine under which conditions data is to be output within the time slot, and/or which data representing information is to be output within the time slot, and/or at which points in time within the time slot the data is to be output; and/or

the data to be transmitted from a first device to one or more second devices is transmitted, together with information which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot within which the devices transmitting no data can output onto the bus data representing specific information, and that settings are made, at least in specific devices, to determine which other devices have to output data within the time slot, and/or which data representing information is to be output

within the time slot by the other devices, and/or at which points in time within the time slot the other devices have to output the respective data ; and/or

5 the device is designed in such a way that the data to be transmitted can be transmitted, together with information which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot  
10 within which the device can output onto the bus data representing specific information, and that settings are made in the device to determine under which conditions it has to output data within the time slot and/or which data representing information it has to output within the time  
15 slot and/or at which points in time within the time slot the data is to be output; and/or

the device is designed in such a way that the data to be transmitted can be transmitted, together with information  
20 which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot within which one or a plurality of other devices can output onto the bus data representing specific  
25 information, and that settings are made in the device to determine which other devices have to output data within

the time slot, and/or which data representing information  
has to be output within the time slot by the other  
devices and/or at which points in time within the time  
slot the other devices have to output the respective  
5 data.

Such methods and devices prove advantageous in many ways:

- on the one hand because, owing to the individual  
10 adjustability of the devices connected to the bus, it is  
possible, under all circumstances, to obtain reliable  
information indicating whether or not the devices for  
which the data to be transmitted is intended have  
received the data in a fault-free condition,
- 15 • on the other hand, because this information can be  
obtained directly after the transmission of the data,  
that is to say for example still in the frame or in the  
message in which the data to be transmitted is  
20 transmitted,
- on the other hand, if necessary, this information can  
also be received later, that is to say for example in a  
frame or in a message in which other data is transmitted,

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- in addition, because there is no necessity to request and/or to transmit the information in one or more separate frames or messages, or - as is the case for example when transmission errors on the CAN bus are displayed - to bring about exceptional circumstances which indicate specific states or events,
- in addition, because the data representing the information can be sent without supplementary information, such as indication of the receiver, of the sender and/or of the significance of the data, owing to the individual adjustability of the devices connected to the bus, and
- finally, because the data representing the information can be output completely independently of the devices connected to the bus, i.e. without triggering or authorization by a device controlling the bus allocation (without arbitration) owing to the individual adjustability of the devices connected to the bus.

The transmission of data can thus be brought about surprisingly easily and at the same time extremely quickly, efficiently and reliably by means of the claimed methods and the claimed devices.

Any other information can also be received from the devices connected to the bus in an equally simple, fast, efficient and reliable fashion.

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Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a method for transmitting data between devices which are connected via a bus, and a device which can be connected to other devices via a bus, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Brief Description of the Drawings:

Fig. 1 is structural diagram showing the basic design of a system with devices connected via a bus; and

Fig. 2 is a schematic showing an exemplary embodiment of the format of a message or of a frame, which is used to transmit data in the method described below and in the device described below.

Description of the Preferred Embodiments:

The method described below is used to transmit data between devices which are connected via a bus; the device described below is a device which is suitable for carrying out the method. A possible design of the system in which the method and the device can be used is illustrated in Fig. 1. Reference is had to the introductory text above. It should be understood, however, that that the invention is not limited to the configuration of Fig. 1. The system can also be of any other desired configuration design.

The term "bus" can be understood to be a communications device which is not connection-orientated and via which data can be exchanged optically, electrically or in some other way between devices which are connected to the bus.

In the example in question, each of the devices N1, N2, ... Nn which are connected to the bus BUS can become bus master; the system is therefore what is referred to as a multi-master bus system. However, there is no restriction to this. The use of

the method described above also proves advantageous if just a single device or only a small number of the existing devices can become bus master.

5 In the present case, the devices N1, N2, ... Nn which are connected to the bus themselves determine who is bus master. This is carried out, as in the case of the CAN bus, taking into account the data transmitted via the bus; as long as a respective device finds again the data output by it on the  
10 bus, it can feel it is the bus master. However, the use of the method described below has also proven advantageous in systems in which the bus master is defined differently, for example by means of a bus controller.

15 The bus BUS of the system in question is supplied on a standard basis with a potential which represents the level 0 and is changed to a different potential "only" if a bit having the level 1 is to be transmitted via the bus. Because the potential representing the level 0 can be drawn, if necessary,  
20 to the potential representing the level 1, bits having the level 1 are designated as dominant bits and bits having the level 0 are designated as recessive bits. It should be apparent that there is no restriction to this. It is, of course, also possible to provide for the bits having level 1  
25 to be the recessive bits and bits having the level 0 to be the dominant bits. The preassignment of a potential representing a

specific level to the bus is carried out in the example in question using what is referred to as pull-down resistors or pull-up resistors which can be provided on devices connected to the bus, or elsewhere. The preassignment of a potential  
5 representing a specific level to the bus proves advantageous but is not a precondition for the method in question here to be applied.

In the example in question, the bus BUS is configured for a  
10 transmission of data which takes place sequentially on a bit-by-bit basis. However, there is not any restriction to this either. The use of the method described below can also prove advantageous if the transmission takes place in parallel or partially in parallel (for example sequentially on a byte-by-  
15 byte basis).

The method in question here is distinguished by the fact that

the data to be transmitted from a first device to one or  
20 more second devices is transmitted, together with information which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot within which the devices transmitting  
25 no data can output onto the bus data representing specific information, and that, in the devices which must

be able to output data within said time slot, settings is made to determine under which conditions data is to be output within the time slot, and/or which data representing information is to be output within the time slot, and/or at which points in time within the time slot the data is to be output, and/or

the data to be transmitted from a first device to one or more second devices is transmitted, together with information which is required or useful for the transmission and/or the use of the data, into units, at least some of which comprise at least one region which defines a time slot within which the devices transmitting no data can output onto the bus data representing specific information, and that settings are made, at least in specific devices, to determine which other devices have to output data within the time slot, and/or which data representing information is to be output within the time slot by the other devices, and/or at which points in time within the time slot the other devices have to output the respective data.

The device in question here is distinguished by the fact that

the device is designed in such a way that the data to be transmitted can be transmitted, together with information

which is required or useful for the transmission and/or  
the use of the data, into units, at least some of which  
comprise at least one region which defines a time slot  
within which the device can output onto the bus data  
representing specific information, and that settings are  
made in the device to determine under which conditions it  
has to output data within the time slot and/or which data  
representing information it has to output within the time  
slot and/or at which points in time within the time slot  
the data is to be output, and/or

the device is designed in such a way that the data to be  
transmitted can be transmitted, together with information  
which is required or useful for the transmission and/or  
the use of the data, into unit, at least some of which  
comprise at least one region which defines a time slot  
within which one or a plurality of other devices can  
output onto the bus data representing specific  
information, and that settings are made in the device to  
determine which other devices have to output data within  
the time slot, and/or which data representing information  
has to be output within the time slot and/or at which  
points in time within the time slot the other devices  
have to output the respective data.

The aforesaid units in which the data to be transmitted is transmitted together with information that is required or useful for the transmission and/or the use of the data and/or further information, are, for example, the frames or messages which are known from already existing bus systems. However, the frames or messages which are used in the method in question here have a structure different from conventional frames or messages.

10 An example of the structure of a frame or a message which is used in the method in question here is illustrated in Fig. 2.

This frame or this message comprises a synchronization field SYN, an identifier field ID, a control field CTRL, a data field DATA, an error detection field CRC, and a reply field REPLY.

The synchronization field SYN, the identifier field ID, the control field CTRL, the data field DATA and the error detection field CRC are filled with data comprising one or more bits in each case, by the device sending the frame or message, and are subsequently - as soon as the respective device can become bus master - output onto the bus sequentially on a bit-by-bit basis. Of these fields,



- the synchronization field SYN receives a specific bit or a specific bit sequence by means of which the start of a frame or of a message is indicated to the other devices;
- the identifier field ID contains one or more bits which specify the type, the contents and/or the receiver of the respective frame or of the respective message;
- the control field CTRL contains one or more bits which specify the length of the data field,;
- the data field DATA contains the data or the message which is actually to be transmitted; and
- the error detection field CRC contains one or more bits which can be used to detect and/or correct transmission errors.

15 The reply field REPLY is not filled with data, or at any rate only filled partially with data, by the device sending the frame or the message. This field thus defines a time slot in which the devices which are not bus master can, or must, output data onto the bus. Depending on the length of the time slot defined by the reply field, one or more bits can be  
20 transmitted via the bus in that time slot.

The information which the data represents and which is transmitted via the bus in the time slot defined by the reply field can be a very wide range of information, for example

5       the signaling from one or more devices connected to the bus that said device or devices has/have received in a fault-free condition the frame or the message of which the reply field is a component (or possibly also a previously transmitted frame or a previously transmitted message or data contained in it), and/or

10       the signaling from one or more devices connected to the bus that said device or devices has/had not received in a fault-free condition the frame or the message of which the reply field is a component (or possibly also a previously transmitted frame or a previously transmitted message or data contained in it), and/or

15       information from one or more of the devices connected to the bus relating to their states (for example relating to the operating mode in which they are in, the utility factor, the temperature etc).

20       Settings which determine which device has to output which information onto the bus at which point in time are preferably made in the respective devices themselves. As a result, the

respective devices can output onto the bus independently, i.e. without triggering or authorization by the device controlling the bus allocation or by some other device, the data to be output by them onto the bus, and can do this at the correct  
5 time.

The corresponding settings in the devices connected to the bus are expediently made before the start of the transmission of the frame or message which contains the reply field,  
10 preferably at the time of initialization of the system which takes place for example after said system is switched on. It proves advantageous if the settings can be varied during operation. This could be brought about, for example, by means of control instructions sent in appropriate frames or  
15 messages. The execution of the setting by means of frames or messages sent via the bus can be used not only when changing the settings but also when making new settings of the devices.

The corresponding settings are preferably stored in

20 nonvolatile memories provided in the respective devices. It is then, under specific circumstances, sufficient if the settings are made only when the system is first put into operation.

Furthermore, it would then also be possible without difficulty (at any rate without repeated settings of the respective

25 devices) for the devices to go in the meantime into an energy-saving operating mode (for example what is referred to as a

sleep operating mode or what is referred to as a power down  
operating mode) during operation.

Which device has to output which information onto the bus at  
5 which point in time can also be set permanently in the devices  
(for example by means of an appropriate hardware  
implementation of the respective devices or using jumpers).

The settings can be made uniformly (identical for all devices)  
10 or individually (differently).

The settings are made in the example in question in such a way  
that the content of the current frame or of a specific  
preceding frame or the content of the current message or of a  
15 specific preceding message, in particular the receivers of the  
frame or message which is specified in it is made to determine  
which device has to output which information onto the bus at  
which point in time. There is thus a frame-specific or  
message-specific use of the reply field.

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The length of the reply field (the length of the time slot  
defined thereby) is not subject to any restrictions and is  
preferably variable; it is expediently in each case precisely  
as long as is necessary to be able to transmit via the bus the  
25 information which is required or desired at this point in  
time.

The data which the individual devices feed onto the bus within the time slot defined by the reply field can be required and evaluated by any other devices, that is to say not only by the  
5 device which sends the respective frame or the respective message. In a system which is the same as or similar to that in Fig. 1, it is, of course, possible for all devices constantly to keep track of whether data is transmitted via the bus, and if appropriate of which data this is.

10 By means of the reply field and the possibility of defining when which device or devices is/are to output which information onto the bus, the devices connected to the bus can obtain, with minimum effort and at maximum speed, the  
15 information which is required for satisfactory operation of the system. This minimum effort and maximum speed is due to the fact that,

20 it is not necessary for the information fed onto the bus in the reply field to be requested in a separate frame or in a separate message and/or to be sent to the devices requiring this information;

25 as a result of the selectability of the devices which are intended to reply, in each case only those devices from which information is required will output information;

as a result of the selectability of the information which  
the selected devices are intended to feed onto the bus in  
the time slot defined by the reply field, only the  
5 information which is actually required is transferred;  
and

as a result of the selectability of the points in time at  
which the selected devices feed onto the bus the selected  
10 information within the time slot defined by the reply  
field, it is possible to determine unequivocally which  
information it is in each case and which information  
originates from which device or from which group of  
devices.

15 Some of the advantages which can be obtained by means of such  
a data transmission method and by means of such devices are  
explained below with reference to a number of selected  
examples.

20 It will firstly be assumed that the device sending the frame  
or the message requires information indicating whether the  
respective frame or the respective message has been received  
by the receiver in a fault-free condition. This can be brought  
25 about by virtue of the fact that

the device for which the respective frame or the  
respective message is intended is set in such a way that  
it outputs, within the time slot defined by the reply  
field or at a specific point in time within the time slot  
defined by the reply field, a positive acknowledge bit  
formed by a dominant bit in the example in question onto  
the bus if up to then it has received the frame or the  
message in a fault-free condition, and it does not output  
a positive acknowledge bit (no dominant bit) if the  
opposite is the case, and

the devices for which the respective frame or the  
respective message is not intended are set in such a way  
that, at least at the point in time at which the device  
for which the respective frame or the respective message  
is intended, they have to acknowledge the fault-free  
reception of the frame or of the message by outputting a  
positive acknowledge bit, do not output any data onto the  
bus or any information indicating whether or not they  
have received the frame or the message in a fault-free  
condition up to then.

As a result, the device sending the respective frame or the  
respective message receives an unambiguous acknowledgement  
indicating whether the frame or the message has arrived in a  
fault-free condition at the device for which it is intended.

In this way, in contrast with a CAN bus, it is not possible for the frame or the message to be sent again even though the receiver for which the respective frame or the respective message is intended has received it in a fault-free condition.

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If the respective frame or the respective message is intended for a plurality of receivers it is possible to provide:

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that the devices for which the respective frame or the respective message is intended are set in such a way that, at different points in time within the time slot defined by the reply field, they output a positive acknowledge bit onto the bus if they have received the frame or the message in a fault-free condition until then, and they do not output a positive acknowledge bit if the opposite is the case, and

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that the devices for which the respective frame or the respective message is not intended are set in such a way that, at least at the points in time at which the devices for which the respective frame or the respective message is intended must be able to acknowledge the fault-free reception of the frame or of the message by outputting a positive acknowledge bit, said devices do not output any data onto the bus, nor any information indicating whether

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or not they have received the frame or the message in a fault-free condition until then.

As a result, the device sending the respective frame or the  
5    respective message receives an unambiguous acknowledgement  
indicating whether the frame or the message has arrived in a  
fault-free condition at each individual device for which it is  
intended. The same result can be obtained,

10    if the devices for which the respective frame or the  
respective message is intended are set in such a way  
that, within the time slot defined by the reply field or  
at a specific point in time within the time slot defined  
by the reply field, they output a negative acknowledge  
15    bit formed by a dominant bit in the example in question  
onto the bus if they have not received the frame or the  
message in a fault-free condition until then, and they do  
not output a negative acknowledge but (no dominant bit)  
if the opposite is the case, and

20    that the devices for which the respective frame or the  
respective message is not intended are set in such a way  
that, at least at the point in time at which the devices  
for which the respective frame or the respective message  
25    is intended must be able to signal the non-fault-free  
reception of the frame or of the message by outputting a

negative acknowledge bit, they do not output any data onto the bus, nor any information indicating whether or not they have received the frame or the message in a fault-free condition until then.

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As a result, the device sending the respective frame or the respective message also receives an unambiguous acknowledgement indicating whether the frame or the message has arrived in a fault-free condition at all the devices for which the respective frame or the respective message is intended. Although, if a transmission error has occurred, it is not possible to determine here which of the devices has not received the frame or the message in a fault-free condition, this is not generally significant because, of course, the frame or the message has to be transmitted again in any case.

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In cases in which it is necessary for specific devices, or for all the devices for which the respective frame or the respective message is intended start the further processing of the data contained in them synchronously (at the same time or at specific time intervals), it is possible to provide that not only the device sending the frame or the message but also the devices for which the respective frame or the respective message is intended monitor the data transmitted in the reply field via the bus, and that the further processing of the data contained in the respective frame or in the respective message

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is not started until it is apparent from the data transmitted in the reply field via the bus that the devices which are to be operated synchronously have received the frame or the message in a fault-free condition.

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It may also prove advantageous, in addition, if at least specific devices for which the respective frame or the respective message is not intended acknowledge, within the reply field, the fault-free reception of the frame or of the message or acknowledge fault-free reception. However, these acknowledgements preferably take place at a different point in time within the time slot defined by the reply field from the corresponding acknowledgement by the devices for which the respective frame or the respective message is intended. If one or more of the devices for which the respective frame or the respective message is not intended signal a faulty reception, this does not have any influence on the transmission of the current frame or of the respective message, but, in particular if it occurs frequently, it permits conclusions to be drawn as to the transmission reliability in the system, and can be interpreted as an inducement to perform maintenance or repair work or to carry out changes in the system structure or in the system components.

25 It may also prove advantageous if individual devices, a plurality of devices or all the devices connected to the bus

are set in such a way that they output a dominant bit onto the bus at different points in time within the time slot defined by the reply field if they have received the frame or the message in a fault-free condition until then and output a

5 dominant bit - in each case at other different points in time within the time slot defined by the reply field - if the opposite is the case. This provides the possibility of monitoring whether the respective devices are still operating satisfactorily or for example - for whatever reason - have  
10 failed. It is possible to assume that the individual devices are still operating satisfactorily if they either signal a fault-free reception or a faulty reception; if one of the devices signals neither a fault-free reception nor a reception fault, or both a fault-free reception and a reception fault,  
15 this is a sign that the respective device is no longer operating satisfactorily.

It should be apparent that individual devices, a plurality of devices or all the devices connected to the bus, including the  
20 device sending a frame or a message, can also feed onto the bus any other information during the time slot defined by the reply field (at specific points in time within that time slot). Such information is, for example, information relating to the operating mode (normal operating mode, energy-saving  
25 operating mode etc.) which the device is currently in, or some

other information which could be of interest for one or a plurality of other devices.

In particular if the data to be transferred via the bus is transmitted with a very high clock frequency, it is possible to provide that the devices are provided with a relatively long time period within which they can feed onto the bus information which is to be fed onto the bus, that is to say the devices can be provided, for example, with a time period in which two or more bits can be transmitted via the bus, in order to output the bit onto the bus. As a result, it is possible to avoid faults which result from the fact that a device is no longer able to feed onto the bus, within a clock period reserved for that purpose, the information which is to be output onto the bus owing to problems with the synchronization with the common transmission clock.

The abovementioned explanations make it clear that the method described for transmitting data between devices connected via a bus makes it possible for data to be transmitted to be transmitted quickly, with a high level of efficiency and nevertheless with absolute reliability.

It should be apparent that the frames or messages here can also have a structure other than that illustrated in Fig. 2.

They may have, in particular, more fields, fewer fields and/or fields representing different contents.